Geophysical Research Abstracts
Vol. 14, EGU2012-9834, 2012
EGU General Assembly 2012

A 500,000-Year-Long Sediment Archive of Lake Van in Eastern Anatolia

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Lake Van, a large terminal lake in eastern Anatolia (Turkey), holds a key position within a sensitive climate region between the Black Sea, Caspian Sea and Mediterranean Sea. Lake Van extends over 130 kilometers on a high plateau; lake level at present is 1665 meters above sea level. The lake water, up to 450 meters deep, is alkaline (pH ∼9.8) and saline (∼21.4‰. Its long and partly annually laminated sedimentary record provides an excellent paleoclimate archive because it yields a long and continuous continental sequence that covers several glacial-interglacial cycles spanning more than 500,000 years. Lake Van is therefore a key site to reconstruct Quaternary climate evolution in the near east. Moreover, being located in a tectonically active area bordered by two historically active volcanoes, it holds a unique paleoseismic and volcanic archive. As a closed and saline lake, Lake Van reacts very sensitively to lake level changes caused by any alterations in the hydrological regime in response to climate change. Because the lake is the deepest lake in Anatolia, which, in contrast to other more shallow lakes, likely never dried out in its history, it was identified as the most promising candidate to contain a long and continuous sediment archive. The drilling campaign, supported by the International Continental Scientific Drilling Program (ICDP), operated by the U.S.-based company Drilling, Observation and Sampling of the Earths Continental Crust (DOSECC), was carried on in July and August 2010. DOSECC developed and assembled a new Deep Lake Drilling System (DLDS) that was specifically designed for coring sediments from deep lakes and that was first operated in Lake Van. The DLDS worked at water depths of up to 360 meters. Cores from 140 meters (Northern Basin site) and 220 meters (AhlatRridge site) below the lake bed depth were retrieved. To obtain a complete sedimentary section, the two sites were cored multiple times. Total length of all parallel cores recovered at the two sites is over 800 meters, allowing a consistent look back in time at the scale of several glacial-interglacial cycles. The cores are stored at an Integrated Ocean Drilling Program's core repository located at the University of Bremen's Center for Marine Environmental Sciences (MARUM) in Germany. This repository's ideal sampling and preparation facilities have been used for splitting, photographic and X-ray fluorescence (XRF) scanning of the core halves, and writing core descriptions and taking samples during spring 2011. Samples have been taken to analyze a variety of characteristics, including paleomagnetics, sedimentology, inorganic geochemistry, black carbon concentrations, pollen species and abundances, isotopes and biomarkers, general composition, and tephra layers. Preliminary single-crystal argon dating of anorthoclase in the tephra, XRF scanning results, as well as pollen analyses, suggest that the Ahlat Ridge record encompasses more than 500,000 years of paleoenvironmental and volcanic/geodynamic history. In addition to the current interglacial stage (marine isotope stage 1), three to four interglacial stages can be identified on the basis of annually laminated lithologies and higher amounts of pollen from trees such as deciduous oak, which favor warmer environments. These submillimeter-scale annual laminations reflect strong seasonal fluctuations in particle supply resulting in alternations of aquatic biomass, authigenic carbonates, and detrital constituents. These warm phases must have coincided with bottom water anoxia and probably coincide with marine isotope stages 5, 7, 9, and 11 or 13. Cold stages are characterized by non-laminated, banded lithologies and predominance of pollen types related to steppe plants. The pore water chemistry as well as the occurrence of freshwater mollusks in sediments from the very bottom at the AR site suggest the initiation of Lake Van as an open freshwater body having an outlet at that time. The recovery of several meter thick tephra layers allows correlation to major dated and compositionally fingerprinted fallout tephra deposits studied on land. Numerous small-scale sediment deformations and seismoturbidites were identified that record earthquake history of this seismically active area. The area's susceptibility for seismic hazards has been once more documented by the magnitude 7.1 earthquake affecting the eastern shore of the lake on October 23, 2011.